INSTRUCTION MANUAL
23J2a
TOOL AND APPLIANCE
ELECTRICAL SAFETY TESTER
CATALOG NO. 235000

BIDDLE

Biddle Instruments

A THORN EMI company

THORN EMI

INSTRUCTION MANUAL
23J2a
TOOL AND APPLIANCE
ELECTRICAL SAFETY TESTER
CATALOG NO. 235000

HIGH-VOLTAGE EQUIPMENT

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user

APARATO DE VOLTAJE ALTO

SIRVANSE LEER ESTE LIBRO CON CUIDADO
ANTES DE OPERARLO

La seguridad es el cargo del operador

BIDDLE INSTRUMENTS
Blue Bell, PA 19422

Feb. 1982

Figure 1: Overall View, Instruction Manual not shown.

TABLE OF CONTENTS

SECTION		PAGE NO.
A	INTRODUCTION	1
	Purpose of The Safety Tester.	1
	Nature of Shock Hazard.	2
	Shock protection provided.	3
	Tests made by Tester.	4
B	SAFETY	6
C	RECEIVING INSTRUCTIONS	8
D	SPECIFICATIONS	9
E	INSTALLATION	13
	Requirements	13
	Additonal Suggestions	14
F	OPERATING PROCEDURE	15
G	FUNCTION OF TESTS PERFORMED & PRINCIPLE OF OPERATION	21
H	PERFORMANCE CHECK	27
I	ROUTINE MAINTENANCE	30
J	REPAIR, TROUBLESHOOTING AND CALIBRATION	32
K	PARTS LIST	35
	Recommended Spare Parts	36
L	WARRANTY	37

FIGURES AND DIAGRAMS

Figure 1	Overall View	-a-
Figure 2	Appliance Ready for Test	14
Figure 3	Location of Controls & Connectors	16
Figure 4	Schematic Diagram	26

TABLES

I	Tests Made on Different Appliance Constructions	4
II	Test Voltages, Current, Thresholds	9
III	Leakage Performance Check	28
IV	Troubleshooting Problem and Cause	32

SECTION A

INTRODUCTION

PURPOSE OF THE SAFETY TESTER

The Biddle Catalog No. 235000 Tool and Appliance Tester provides facilities on shipboard for reliable testing of electrically operated tools and appliances for possible shock hazard. This portable, compact, easy-to-use Test Set will perform the required tests in the shop or at the job site.

Testing is done to assure safe operation of tools. Electrically operated tools or appliances are subject to a lot of wear and deteriorating conditions and even the best designed and built equipment may eventually become a shock hazard. A shock that only startles the user may indirectly cause injury; as an example, by causing a person on a ladder to misstep and fall. It is therefore good to test often, repairing or discarding faulty equipment, to prevent injury and possibly saving life. There is more information on shock hazard and testing later in this Section.

This Test Set will perform the necessary safety tests on equipment that operates from 120 volts, 60 Hz and drawing up to 15 amperes. It is specially designed for the conditions found on ships;

The Test Set,

a. will operate on the local ungrounded power system.

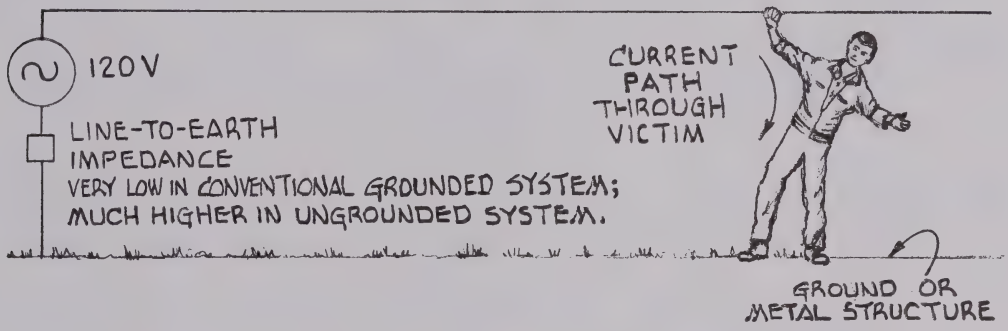
b. is portable so it can be taken to the equipment to be tested.

The Test Set will also operate on grounded power systems; however, if the intended use is mainly with a grounded system, Biddle recommends an alternate version of the set which provides greater shock protection to the user.

CAUTION: The Tester itself may cause serious electrical shock to user or bystander during use in the Leakage mode. For your protection, follow the procedures under SAFETY, Section B, and OPERATING PROCEDURE, Section F.

NATURE OF THE SHOCK HAZARD IN APPLIANCES

The greatest electric shock hazard exists when the user is in electrical contact with the "earth". This occurs, for example, when a user is actually standing on the earth or a concrete floor, or touching a metal water or heating pipe which runs to the earth or any metal part of a metal building or ship. The electric shock may occur if a person thus "grounded" comes into electrical contact with one of the wires (the bare copper) of the 120-volt power system. If the other wire of the 120-volt system is connected to the earth, the 120 volts are applied across the person as shown below:



The severity of the shock depends on how much current flows in the victim. This in turn depends on the "resistance" of his contacts to the earth and to the power line. If both contacts have low resistance, the victim can be electrocuted. If one or both contacts have medium resistance, he may be "frozen" unable to free himself until released. With a higher resistance, he will only feel a jolt, and will immediately let go of the live object; he will be unharmed unless he has a bad heart or falls off a ladder. With an even higher resistance, the person will feel nothing at all.

SHOCK PROTECTION PROVIDED IN APPLIANCES

Appliances are made with one or two levels of protection for the user to prevent his touching the bare 120-volt power line. The first protection is a covering of electrical insulating material which prevents the user from contacting the actual wire or anything connected to it. Most modern appliances, and in particular all those intended for outdoor or industrial or military use, also have a second level of protection. The second protection may be a second layer of insulation; in this case the appliance is referred to as "double-insulated" and may be so marked by the box-in-box symbol " ". Double-insulated appliances have two-wire line cords and plugs.

Another form of second protection is a metal frame enclosing the electrical components and wiring (and their insulation). This frame is connected to ground by a third (green) wire in the line cord. The frame gives protection only if it has a low-resistance connection to ground. Appliances having this construction are referred to as "grounded"; they have 3 wire line cords and plugs. The ground is the round pin of the plug.

Some appliances, especially older ones intended only for use in the home, do not have a second protection. They rely on the fact that in a dry indoor environment the user seldom has a good connection to earth.

On shipboard, although the user is very likely to be well-grounded, some additional protection may be provided when an ungrounded power system is used. By eliminating a direct connection to ground the current path through the victim is seemingly broken (see sketch); actually there may be a great deal of leakage current or even an accidental good connection somewhere in the wiring of the ship which will make the "ungrounded" system behave the same as a grounded one.

TESTS MADE BY THE TESTER

The Tester tests the various levels of protection as follows:

TABLE I - TESTS MADE ON DIFFERENT APPLIANCE CONSTRUCTIONS

TYPE OF SHOCK PROTECTION USED IN APPLIANCE	TESTS MADE BY TESTER		
	GROUND CHECK	LEAKAGE	INSULATION BREAKDOWN
Grounded	X	X	X
Double-Insulated	NO	X	X
Neither of above (2-wire cord, single insulation	NO	X	X

Ground Check Test

This tests the adequacy (low resistance) of the connection through the green wire between the frame or other exposed metal parts of the appliance and the ground pin in the line plug. The Biddle Tester uses a very high current to detect connections which are nearly worn through; it does this by burning them completely open. This method is superior to the ordinary continuity test using a pen-light; it is preferred by the most conservative users.

The ground check is extremely important on all three-wire extension cords as well as appliances.

Leakage Test

This test is made with the appliance energized and operating. This shows defects which might only occur during heating or motor-driven operation of the appliance. It actually measures the current which could flow through a grounded person holding onto the appliance while it is in operation. In other words, it measures the current that "leaks" through or around the insulaton.

On "grounded" tools, this test measures the current through the green ground wire. This means that it measures the current a victim might receive if the ground wire were accidentally opened and he were there to serve in its place. Thus the first two tests make separate and independent checks on the two protections of a grounded appliance.

On double-insulated tools, the leakage check will ordinarly be applied to exposed metal parts of the appliance. Thus the tester tests both layers of protective insulation at once. There is no separate check for each layer unless the appliance is disassembled.

On 2-wire appliances of the domestic type which may not be double-insulated, the test is made in the same way on all accessible metal parts.

Insulation Breakdown Test

This test is made on a non-energized appliance. It applies a voltage several times the normal rating across the protective insulation, whether single or double. The connections are made to the two power wires connected together and to the frame, either through the ground wire or through a special test probe. This test is meant to find weak spots in the insulation which do not show up in the leakage test but which might fail in the future.

Summary of Testing

The Cat. No. 235000 Electrical Safety Tester provides all of the electrical tests needed to check ordinary 120-volt tools and appliances for shock hazard. It should be used as part of a comprehensive program including regular visual inspection, functional tests, careful repair and maintenance, and alertness on the part of users. Such a program will prevent accidents.

SECTION B

SAFETY

The Biddle Tool and Appliance Safety Tester and the recommended operating procedures have been designed with careful attention to safety.

The purpose of the test setup is to locate electric shock hazard of the equipment under test. Because of this purpose a shock hazard exists for the user if the procedures given are not carefully and consistently followed.

HIGH-VOLTAGE EQUIPMENT

PLEASE READ CAREFULLY BEFORE OPERATING

Safety is the responsibility of the user

The equipment under test must be treated as a shock hazard until proven safe by the tests performed according to the procedures given in this manual.

Tools and appliances may have mechanical or physical hazards as well as electrical ones. Those persons performing the tests must assume responsibility for preventing injury from rotating shafts or cutting edges of tools and must handle the equipment to prevent injury due to vibration, movement or heating when the equipment is operating.

Before conducting any tests, read the entire manual and carefully follow the procedures for testing.

Safety will be enhanced if test procedures are practiced until they are completely learned before evaluating equipment to be placed in general service.

To meet the special requirements on ships, as well as to make a complete safety test, it has been necessary to expose the Test Set user to a possible shock hazard. To minimize this possible hazard Biddle recommends that the user keep safety in mind at all times. Read and follow procedures of the operating section and safety recommendations throughout this manual.

SAFETY (cont'd)

The Test Set produces dangerous voltages. The significant shock hazard occurs during the LEAKAGE test, while the "Accurate Leakage" switch is operated. This step can be omitted, or if conditions warrant, the switch can easily be disabled. These points are discussed in more detail in Section J.

When a grounded power system is available we recommend the use of a Biddle Test Set designed for use only on such systems. These Test Sets do not have the particular hazard just mentioned.

Because there are dangerous voltages inside the case, the Tester must never be operated with the case removed. Repairs to the Test Set should be made in accordance with the precautions noted in the Repair Section and only by qualified personnel.

SECTION C

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify Biddle Instruments, Blue Bell, PA of any shortage of materials.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify BIDDLE Instruments or its nearest authorized sales representative, giving a detailed description of the damage observed.

This instrument has been thoroughly tested and inspected to meet rigid inspection specifications before being shipped. It is ready for use when set up as indicated in Section E. The performance check of Section H may be used to insure that the Tester is fully operational.

SECTION D

SPECIFICATIONS

TEST MODES

1. Ground conductor resistance check.
2. Line Voltage Leakage Tests:
   Pre-Test (Not operating, 120V both lines to frame).
   Operating, Limited Current (120V, each line to frame).
   Operating, Full Accuracy (120V, each line to frame).
3. Insulation Breakdown (frame to both lines).

TABLE II - TEST VOLTAGES, CURRENTS, THRESHOLDS

TEST MODE	APPLIED VOLTAGE RMS, 60 HZ	TEST CURRENT LIMIT	TEST PASS/FAIL THRESHOLD
Ground Continuity	5V max. One side grounded.	25A	0.15 ohms (approx.)
Leakage, Pretest	120V Isolated.	2mA	0.5mA (approx.)
Leakage, Operating, Limited Current, Normal*	120V (AC line) thru 25000 ohms.	5mA	"
Leakage, Operating, Limited Current, Reverse*	120V (AC line) thru 25000 ohms.	5mA	"
Leakage, Operating, Full Accuracy, Normal*	120V (AC line) thru 5000 ohms.	25mA	"
Leakage, Operating, Full Accuracy, Reverse*	120V (AC line) thru 5000 ohms.	25mA	"
Insulation Breakdown	0 to 1500V one side grounded.	3mA	1mA

* In the "Normal" connection, current is measured from the black power wire to the frame; in the "Reverse", from the white wire to the frame.

SPECIFICATIONS (cont'd)

TEST DUTY CYCLE

Ground Continuity:	10 minutes per hour.
Others:	continuous

METERING

Leakage Meter:	3 1/2-inch taut band
Scale	0-10mA AC, quasi-logarithmic, with 1mA near center scale. Color coded bands: Green "GOOD" ; 0-0.25mA Red "STOP TEST-DANGER" 0.5-10mA
Accuracy (in Accurate Leakage mode).	At 0.5 mA: ±5% of reading. At 0.25, 1, 5 and 10mA: ±5% F.S. (±.15 inches)
Voltmeter for Insulation Breadkown	3 1/2 inch taut band
Scale:	0 - 1500 V RMS
Accuracy:	±5% F.S.

INDICATORS

Ground Check ON:	Neon Lamp.
Ground Check result:	White lamp for GOOD indication.
Caution:	Flashing red lamp indicates tester is operating in Leakage or Insulation Breakdown mode.
Buzzer:	Audible alarm indicates insulation breakdown.

CONTROLS

Test Selector Switch:	4 Position: OFF, (1) Ground, (2) Leakage, (3) Insulation Breakdown.
Leakage Selector Switch:	Normal (UP),Reverse (DOWN),spring return to Pre-test, (CENTER).
Leakage Current Meter Check:	Pushbutton Switch.
High Accuracy Leakage Test:	Pushbutton Switch.
Voltage Control:	Variable Transformer sets Insulation Breakdown Test Voltage.

SPECIFICATIONS (cont'd)

TEST CONNECTIONS

3-wire isolated-ground receptacle on tester panel for power plug of appliance under test.
Case lid serves as insulating holder for appliance under test; metal plate contacts frame of appliance under test.
Separate test probe with 3-foot lead and removeable clip to connect to contact plate in lid or directly to frame of appliance.

PHYSICAL

Dimensions:	13 1/4" wide, 10" deep, 10" inches high (33.7 x 25.4 x 25.4 cm).
Weight:	21 pounds (9.5 kg)
Input cord length:	8 ft.(1.5 meters)

POWER SUPPLY

Voltage:	120V RMS
Current:	15 amperes RMS max. continuous
Frequency:	60 Hz
Service:	Single-phase ungrounded neutral with separate ground wire.

APPLICATION

Performing Electrical Safety Tests on cord-connected tools and appliances having the following ratings:

Voltage:	110-125 volts RMS
Current:	15 amperes RMS max. continuous
Frequency:	60 Hz
Service:	Single Phase

USER SAFETY FEATURES

- Panel instructions call attention to safety practices.
- Instruction Manual gives instructions for safe use and maintenance.
- Continuity test voltage is limited to 5 volts.
- Red Caution lamp flashes when Leakage or Insulation test is on.
- Leakage test is made in three steps; most defective appliances are weeded out in the first two steps which offer no serious shock hazard to the operator. The final "Accurate Leakage" step, although it may present a significant hazard, provides the following protections:

    a. The test can usually be omitted (always, if desired).
    b. Two hands must be used to energize the test.
    c. The hazard exists only if the ship's isolated power supply has an unbalanced ground fault on the order of 20,000 ohms or less.
    d. The current is still absolutely limited to 25mA; this is recognized as dangerous to life only if sustained for many seconds.

- Insulation Breakdown short circuit test current is limited to 3mA by high reactance transformer.

SECTION E

INSTALLATION

The Tool and Appliance Electrical Safety Tester is a portable unit, but it is also readily adapted to permanent installation.

INSTALLATION REQUIREMENTS

Select a working area conforming to the following:

a. Sufficient room for the Test Set and operator with clearance from the equipment to be tested.

b. Suitable barriers to prevent access by unauthorized persons during testing.

c. Area that is dry and free of traffic hazard.

d. Service outlet within 8 feet of testing location.

e. Service outlet wired with a proven ground (for the green wire of the input cord).

f. A secure insulated mounting for equipment under test. The insulation must isolate the equipment under test from ground and any adjacent conductors. As a convenience, the Test Set lid can be used but operating equipment may require securing the equipment to the lid. See Figure 2. Alternatively it is suggested that a rubber electrical insulation blanket or a suitable piece of acrylic or phenolic plastic be used.
DO NOT USE STATIC DRAIN MATS.

If it is necessary to use an extension cord between the Test Set and service outlet, a high quality heavy duty cord of 3-wire type rated for at least 20 amperes is needed. The use of an extension cord should be avoided if possible.

CAUTION

Arrange the work space so that you can reach the controls without any danger of touching the appliance under test, the test probe, or the lid contact plate. Rubber gloves or shoes are not required, but Biddle considers their use an excellent safety precaution when handling the test probe or equipment under test.

ADDITIONAL SUGGESTIONS FOR PERMANENT INSTALLATION

It is recommended that a sturdy wood work bench be used. A simple support may be provided to hold the entire unit at a convenient angle and position with the Test Set case secured to the support. A location on the work bench preferably to the right of the Test Set may be arranged so that the equipment to be tested can be securely clamped in place and insulated from ground. Barriers are strongly recommended to prevent accidental contact with the equipment under test.

As a refinement, the service outlet for the Test Set may be interlocked with the access barrier for the equipment under test.

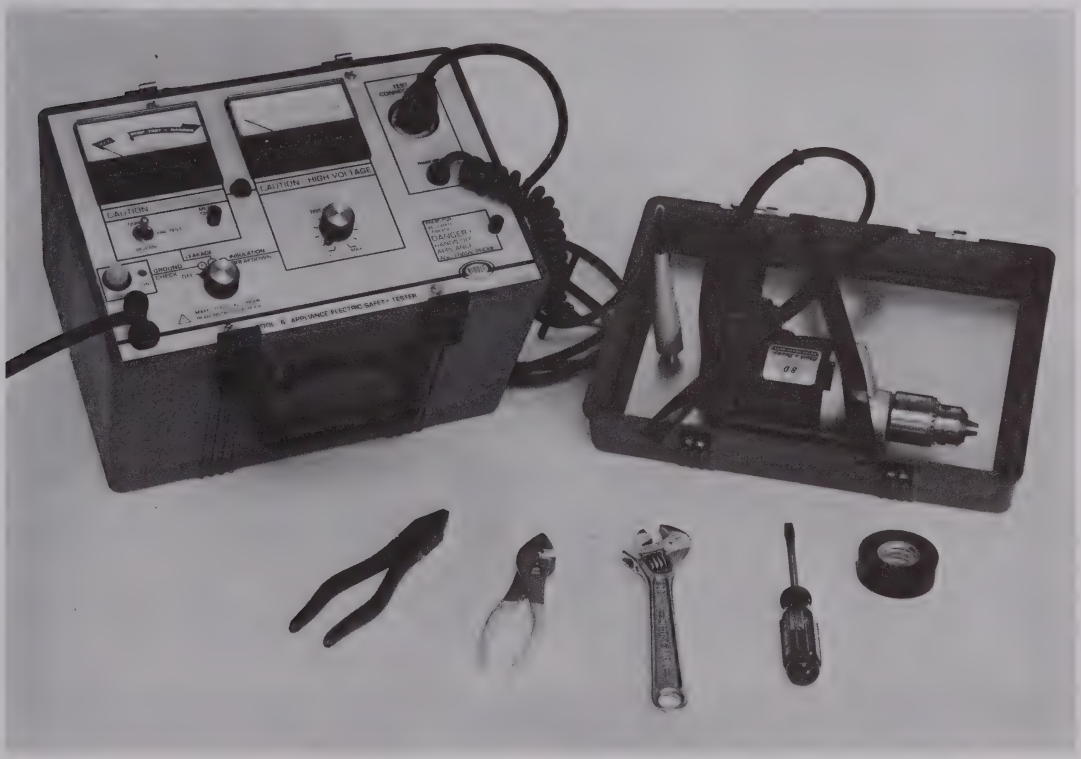


FIGURE 2: APPLIANCE READY FOR TEST
Electric drill installed in lid of Tester ready for testing. Note the electricians tape used to restrain the tool during operating leakage test. DO NOT TOUCH TOOL, PROBE OR CONTACT PLATE DURING LEAKAGE TEST.

SECTION F

OPERATING PROCEDURE

PRELIMINARY

Before testing begins, make a visual inspection of the Appliance Under Test (AUT). In the case of a power tool, the housing should be wiped off and the cooling vents blown clear with compressed air. Then carefully inspect the line cord for frayed wire and the plug for a cracked housing or a broken pin. Review any damage reports, if submitted. Repair visible defects before testing.

SETUP FOR TESTS

Install the Tester as described in Section E, Installation. Refer to Figure 3, next page, for location of controls.

With due regard to safety, follow the steps below:

a. Set the MODE selector switch to the OFF position.
b. Connect the Test Set to the proper service outlet.
c. When the lid plate is to be used, connect the frame probe to the wing nut.
d. Secure the AUT to the lid (if used) or to a well insulated stable surface. (AUT must be insulated from ground, or leakage test is not valid). See Figure 2.

   The AUT must be securely mounted so as not to pose a hazard during the operating leakage test if it is motorized. Take precautions to prevent injury to personnel or equipment by cutting tools, moving parts, or heating elements.

   When testing an extension cord (3-wire only), coil the cord up in or on the lid and plug the ground socket (round hole) onto the round pin on the lid plate.

e. Make sure the Test Set switch is set to OFF, set the AUT power switch ON, and plug it into the service outlet of the Test Set. If necessary tie or tape the AUT power switch ON. See Figure 2.

Before proceeding, check the ground (green wire in line cord) connection of the Tester itself as follows:

Remove the probe from the lid and touch it to a nearby grounded pipe or structure. Turn to Ground check. The GOOD lamp must light as described in Performance Check, Section H. If not, repair the Tester cord or the power source wiring before proceeding.

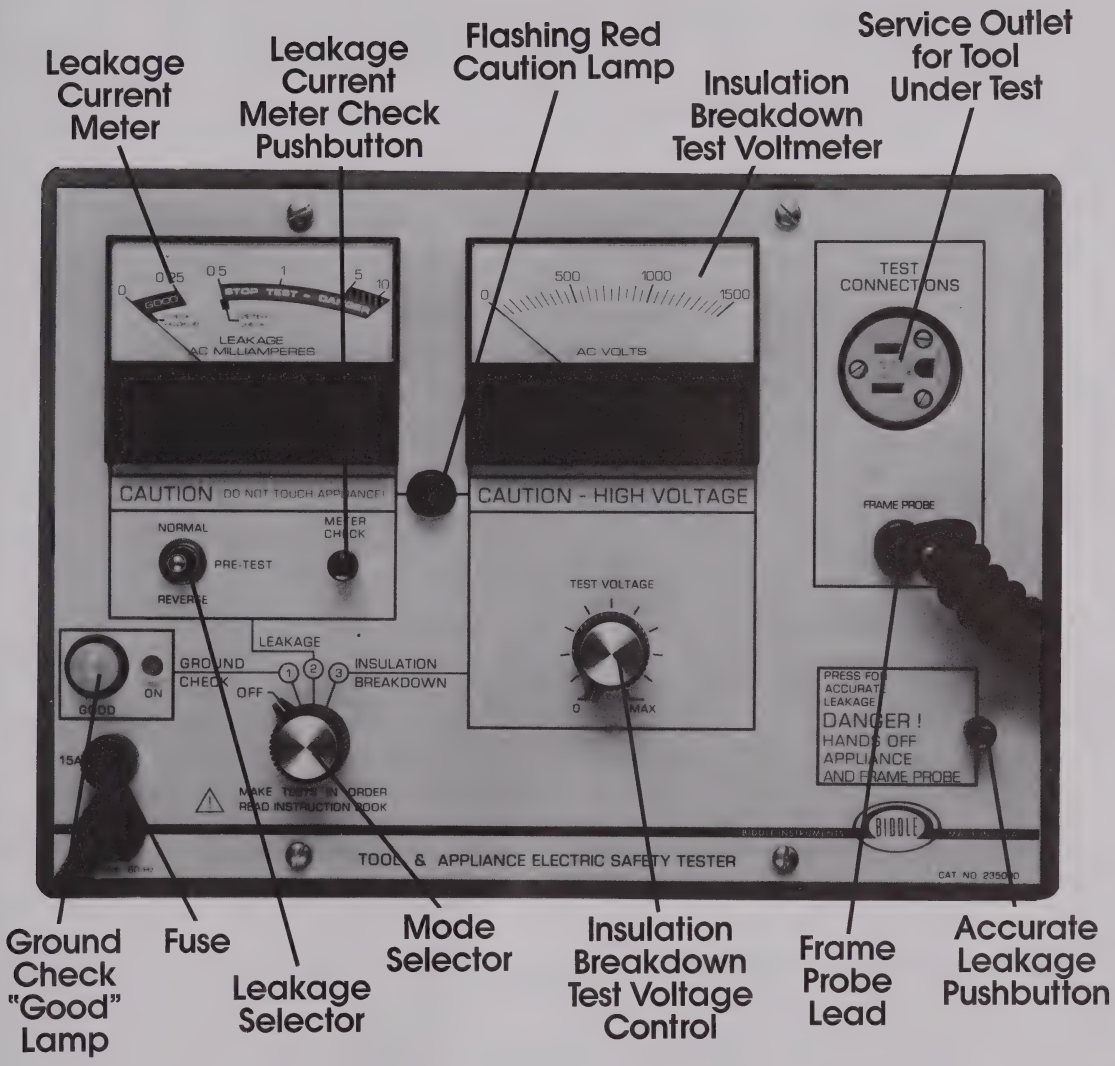


Figure 3: Location of Controls and Connections.

MAKING TESTS

NOTE: Make tests in the order listed below (1-2-3 on the Mode selector switch). If any test has failed, repair the AUT before proceeding!

A. Ground Check (Used only on appliances having a 3-wire cord).

1. Set the Mode selector switch to the GROUND CHECK (1) position.

   1.1 The ON lamp must light.

2. The probe must contact the AUT frame or housing.

   2.1 If the contact plate in the lid is used, be sure that the AUT housing makes good contact to the plate.
   2.2 If the lid plate is not used, or if contact to plate is uncertain, apply the probe directly to the AUT frame or housing. (A poor contact will prevent even a good appliance from passing this test.)
   2.3 Test all exposed metal parts.

3. For acceptance the GOOD lamp must be bright.

4. If the GOOD lamp does not light, DO NOT PROCEED with testing. The appliance is not safe. Set the selector to OFF and remove the AUT for repair or correction.

B. Leakage, Meter Check and General

It is recommended that during these tests no contact be made with the AUT unless the Mode selector switch is in the OFF position.

1. With the AUT ON, set the Mode selector switch to the LEAKAGE (2) position.

   1.1 The CAUTION lamp will flash red during all Leakage Tests.
   1.2 The Test Set is now in the Pre-test mode.

2. Press the Meter Check pushbutton; the Leakage Meter should read within the meter check band.

2.1 If this condition is not met, check the supply voltage. Tests may require qualification if the voltage is markedly different from the nominal 120 volts ,i.e. the meter reads above or below the scale mark. To make correction, multiply the leakage reading in mA by the ratio of 120 divided by the actual line voltage.

3. Sequence of Leakage Tests

3.1 The Pre-Test is a quick, relatively safe test to detect very bad faults. If the meter indicates in the red above 1 mA, repairs should be made before proceeding.

3.2 The Operating Tests (Normal & Reverse) made without pressing the "Accurate Leakage" button make a full operating test. A current limiting resistor to protect the operator causes readings to be low by about 10 to 20%. (The words "Normal" and "Reverse" refer to the line connection, not to any direction of operation).

3.3 Pressing the "Accurate Leakage" button during the Normal and Reverse operating tests removes the protective resistor and gives a reading at full accuracy.

In this condition, the Frame Probe and the green wire and frame of the AUT are connected to one side of the line, so THE APPLIANCE UNDER TEST AND THE FRAME PROBE MUST BE GUARDED FROM CONTACT BY ANY PERSON OR ANY OTHER CONDUCTOR!

Omit this test unless a full accuracy reading is required. If the current-limited test (3.2) gives a reading below 80% of the allowable limit, the full accuracy test can be assumed to pass also.

C. Leakage, Pre-Test (Appliance Not Operating)

1. Release the "Meter Check" pushbutton and observe the leakage meter for a Pre-Test reading.

1.1 If the meter indicator is well into the red zone, DO NOT proceed until the AUT has been repaired.

1.2 If the meter indicator is in the green or white zones (0 to .5 mA) proceed with the "Normal" and "Reverse" Leakage Tests.

1.3 If the leakage is at zero there may be a bad connection. Recheck connections before proceeding.

D. Leakage, Appliance Operating (Current-Limited)

1. Move and hold the Leakage Selector switch to the "Normal" position. Watch the leakage meter as the appliance operates (motor runs, heater heats, etc). Read the Leakage after the AUT stabilizes in its normal operating condition.

2. Repeat as above, holding Leakage Selector in the "REVERSE" position.

E. Accurate Leakage, (Appliance Operating)

CAUTION

This test may present a shock hazard to the operator; follow all safety recommendations! DO NOT TOUCH THE AUT OR THE FRAME PROBE DURING THESE TESTS.

1. To perform "Accurate Leakage" ("Normal" and "Reverse") tests, proceed as in Step D, using one hand to hold the Leakage selector in the appropriate position. With the other hand press the "Accurate Leakage" pushbutton. While both switches are operated, and after AUT has stabilized, read the Leakage Meter.

NOTE: The Accurate Leakage test is normally only used when the current-limited Normal or Reverse Leakage is well into the white zone. The Accurate test then reveals just how close the leakage is to the red zone. Some users may prefer to rely on the limited current test and not perform the "Accurate Leakage" test with its possible shock hazard.
If this action is decided on, see the Repair Section for the disabling of the Accurate Test.

F. Insulation Breakdown

1. Set the Test Voltage control to zero.

2. Set the Mode selector switch to the Insulation Breakdown (3) position.

   2.1 The red CAUTION lamp will flash.

3. Raise the voltage by clockwise rotation of the Test Voltage control. Set the Test Voltage to the required value, usually 1000 volts, by observing the AC VOLTS meter.

4. A failure of the AUT will be indicated by the sounding of the alarm buzzer. Also the voltmeter reading may fluctuate or drop suddenly.

   4.1 If failure occurs, quickly return the Test Voltage control to zero and the Mode Selector switch to OFF. Examine and repair any AUT that has failed this test before putting it into service.

G. Shutdown

1. Testing can be stopped at any time by moving the Mode Selector switch to the OFF position.

2. Set the Mode Selector switch to OFF whenever connecting or disconnecting the AUT.

H. Testing Extension Cords

Extension cords are tested by the same procedures as used for other items. The Ground Check is a test of green wire continuity. The Leakage and Breakdown tests are applied between the green wire and the black and white wires. Note that the Leakage and Breakdown tests are applied only to the insulation between conductors within the cord. Leakage from a supply conductor through the outer cable jacket is not checked unless special arrangements are used.

SECTION G

FUNCTION OF TESTS PERFORMED AND PRINCIPLE OF OPERATION

GROUND CHECK

This test applies only to apparatus having a 3-wire line cord. Its purpose is to insure that the metal frame of the Tool or Appliance is connected to the ground pin of the line plug. This important connection is subjected to a low resistance continuity test. A high test current (25 amperes) is used; this simulates a heavy ground fault and assures the ability of the ground circuit to carry enough current to blow a fuse. (A frayed wire with only one or two strands left will melt open and force a repair.) Refer to the schematic circuit diagram of Figure 4 at the end of this section.

The Test Set performs the ground check test when S1 is set to Ground (1) position. Transformer T2 primary is energized from the supply in series with the GOOD indicator lamp DS7 (shunted by R33) and resistor R11. The presence of supply voltage is indicated by pilot lamp DS8 (in series with R22). The secondary of T2 (two 5-volt windings in parallel) is the source of the testing voltage. The current path of T2 secondary is traced from T2 to the ground pin of J2 and so to the apparatus under test (AUT), assuming continuity, to the frame of the apparatus. The current path is completed by the Frame probe connection to the frame of the AUT back to the T2 secondary.

The secondary current in T2 is reflected back to the primary and causes the GOOD lamp DS7 to have sufficient current to light at full brilliance. A resistance path above 0.15 ohms in T2 secondary will limit the current so that the GOOD lamp will be dim or not light.

This test should not be operated continuously with the GOOD lamp at full brilliance for more than 3 minutes to prevent overheating of the transformer.

LEAKAGE

The leakage tests determine if a conductive path exists for excessive "leakage" current between the frame of the AUT and either wire of the power line. Such leakage is a direct shock hazard.

Because leakage testing is so important, the Test Set is equipped with a self-testing feature to verify all leakage measurements. The Test Set performs this function when S1 is in the Leakage position. The supply voltage is applied to the primary of T5 (1 and 4). The presence of supply voltage causes the caution lamp

DS5 to flash at a rate of about 3 flashes per second because of the relaxation oscillator formed by CR9, R3, C1 and DS5. The secondary of T5 between the terminals of 5 and 8 develops a voltage proportional to the supply voltage. When the meter check switch S5 is closed between PC card terminals 11 and 13, transformer T5 secondary passes current through the loop R37, R38, R16, R17, R19 and the Leakage Meter circuit so that with a line supply of 120 volts the leakage meter M3 will read at the index (0.5 mA).

The leakage meter circuit uses a dc meter converted for ac by rectifiers CR12 and CR10. Resistor R20 sets the meter sensitivity at 0.5 mA while R32 allows adjustment at 5 mA. Rectifier CR12 is a zener diode; in combination with R18 it completes the meter circuit and provides the non-linear meter scale. It also provides overcurrent protection. Capacitor C3 minimizes leakage meter response to high frequency current components, such as caused by brush sparking. (High frequencies have less effect on humans, so the ANSI C101-1 standard specifies this response.)

Leakage testing is done in 3 stages so as to minimize shock hazard to the operator as detailed in Section A Introduction.
THE FIRST STAGE IS PRE-TEST

This is performed with the apparatus under test not operating; S1 is in the Leakage position with S5 not operated. The primary of T5 is energized exactly as for Meter Checking but the secondary of T5 drives current through the loop traced from T5 terminal 8 through the current meter circuit then through R19 to the ground pin of J2, then to the frame of the AUT. The path continues through the "leakage" between the frame and both legs of the supply cord of the AUT back to J2. Relay section K2-1 are closed 3 to 7 and section K2-2 contacts are closed 4 to 8 so the leakage current passes through R26 and R27. The sum of the currents in R26 and R27 pass through R25 and R37 to return to T5 secondary at terminal 5.

During Pre-Test the shock hazard to the user is very small. Transformer T5 isolates the AUT from the supply line. This protects any grounded person who might touch the AUT (during Pre-Test only). A further protection is the high resistance of the Pre-Test circuit which limits the test current to less than 2 mA.

THE SECOND STAGE IS OPERATING LEAKAGE TESTING.

In this test the AUT is operating. The leakage between the equipment frame and the supply is measured. In the "Normal" test the black lead is considered above ground potential. In the "Reverse" test the white lead is considered above ground potential. For ungrounded services the "Normal" and "Reverse" test are of equal importance.

The Test Set performs operating leakage tests when S1 is in the leakage position, and the Leakage selector, S4, is in the "Normal" or the "Reverse" position. The supply source is connected to the AUT at J2 with the white and black supply leads to J2 interchanged between "Normal" and "Reverse" switch positions. Simultaneously the supply voltage is applied to the primary of T5 and relay coil K1. The red caution lamp continues to flash. When K1 is energized relay contact K1-12 closes from 11 to 23 (and opens 5-6) so that the current meter is transferred to measure one leg of the supply in series with resistor R36. The leakage current now will pass from the one side of the source through R36, the current meter circuit, resistor R19, then through the meter check switch S5 to the ground pin of J2. The path continues to the frame of the AUT, then through any leakage paths to the other side of the supply source. Meter M3 now measures this "leakage" current. The principle limiting of the leakage current is due to resistor R36 whose value has been selected so that the maximum leakage current is limited to the relatively safe value of 5 mA. The presence of R36 makes the measured current a little lower than it would otherwise be. This error is a function of the leakage path in the AUT depending on whether the paths are resistive or capacitive in nature. The error magnitudes at 0.5 mA is neglible if the path is capacitive, but may be as much as 10% if the path is resistive. For larger leakage current the error increases.

THE THIRD STAGE OF LEAKAGE TESTING IS ACCURATE LEAKAGE.

This test measures the leakage current accurately in the "Normal" or "Reverse" tests while the AUT is running. The Test Set performs this function when Accurate Leakage pushbutton, S6, is held closed to bypass the current-limiting resistor R36, allowing a greater leakage current to pass through the circuit detailed for "Normal" and "Reverse" leakage. (The term "accurate" refers to the ANSI C101.1 specification that defines the leakage as the current measured when a meter of specified impedance is used; it does not refer to the meter movement.)

SHOCK HAZARD

With R36 bypassed, the frame of the AUT is connected to one side of the line with only R19 as a protection. In case the other side of the line is grounded through a fault in the system or the AUT leakage, a grounded person touching the AUT could get a nasty jolt.

Although R19 limits this current to 25 mA, this is in the range that can cause a person to freeze and be unable to let go, while being unable to breathe. For this reason, the Tester requires the operator to use both hands to set up this test; one hand on the "Normal"/"Reverse" switch, the other to operate the "Accurate" pushbutton. This prevents the operator from handling the equipment under test during the Accurate Leakage test. He must also make sure no other person touches the setup!

INSULATION BREAKDOWN

The object of this test is to again evaluate the insulation between the equipment frame and the supply cable. It differs because the voltage used is higher than the supply voltage and consititutes an ac high potential breakdown test. The equipment is not operating during this test.

The means of making this test can be understood from the schematic, Figure 4.

Setting S1 in the Insulation Breakdown position energizes relay K2 so its contacts close at K2-1 from 3 to 5 and open 3 to 7; also contacts at K2-2 open 4 to 8 and close 4 to 6. This connects the equipment supply leads together. Closing S1 also lights the flashing red caution lamp DS5 via rectifier CR5, components R3 and C1, with CR5, form the flasher circuit . Simultanously the variable autotransformer T3 is energized. Buzzer LS1 is not operative because SCR,(Q1), is not turned on. The variable arm of T3 is the voltage control and sets the primary voltage to step-up transformer T4 which is of high reactance design. The secondary of T4 develops a voltage and has a limiting resistance R29 in series. The voltage developed across the output of T4 is measured by the ac voltmeter consisting of voltage divider resistor R4, rectifiers CR3 and CR4 and meter M2 with calibrator R7. The output of the limiting resistor R29 is connected to the paralleled supply leads of the AUT by K2.

The frame of the AUT is connected to ground through the frame probe (and also through the green wire, if any) and S1-3. The

secondary return of T4 (terminal 3) also is connected to ground through the optically isolated current detector circuit consisting of "V1 lamp", R10, R9 and C2. Secondary current from T4 will include any current passing from the supply leads to the frame of the AUT and must pass through the detector. In normal small appliances, this current is under 1 mA at 1000 volts. In this case, the current, passing through R9 does not develop sufficient voltage to light neon lamp V1. However, if the insulation should breakdown (spark or arc) or be defective in some other way, a higher current will flow, lighting V1 lamp.

V1 lamp is part of the optical isolator assembly which also includes a photo conductive cell, V1 cell. When V1 lamp lights it causes V1 cell to change from a very high resistance to a low resistance; this raises the voltage across R12 and triggers the SCR Q1. The current through VI cell is limited by R14 but when T4 secondary supplies one milliampere of leakage current Q1 is triggered. This causes Q1 to turn on the buzzer alarm LS1. Rectifier R6 protects Q1 and provides the desirable pulsed dc gate for Q1. The buzzer remains energized as long as the leakage current exceeds the predetermined level of about 1 mA.

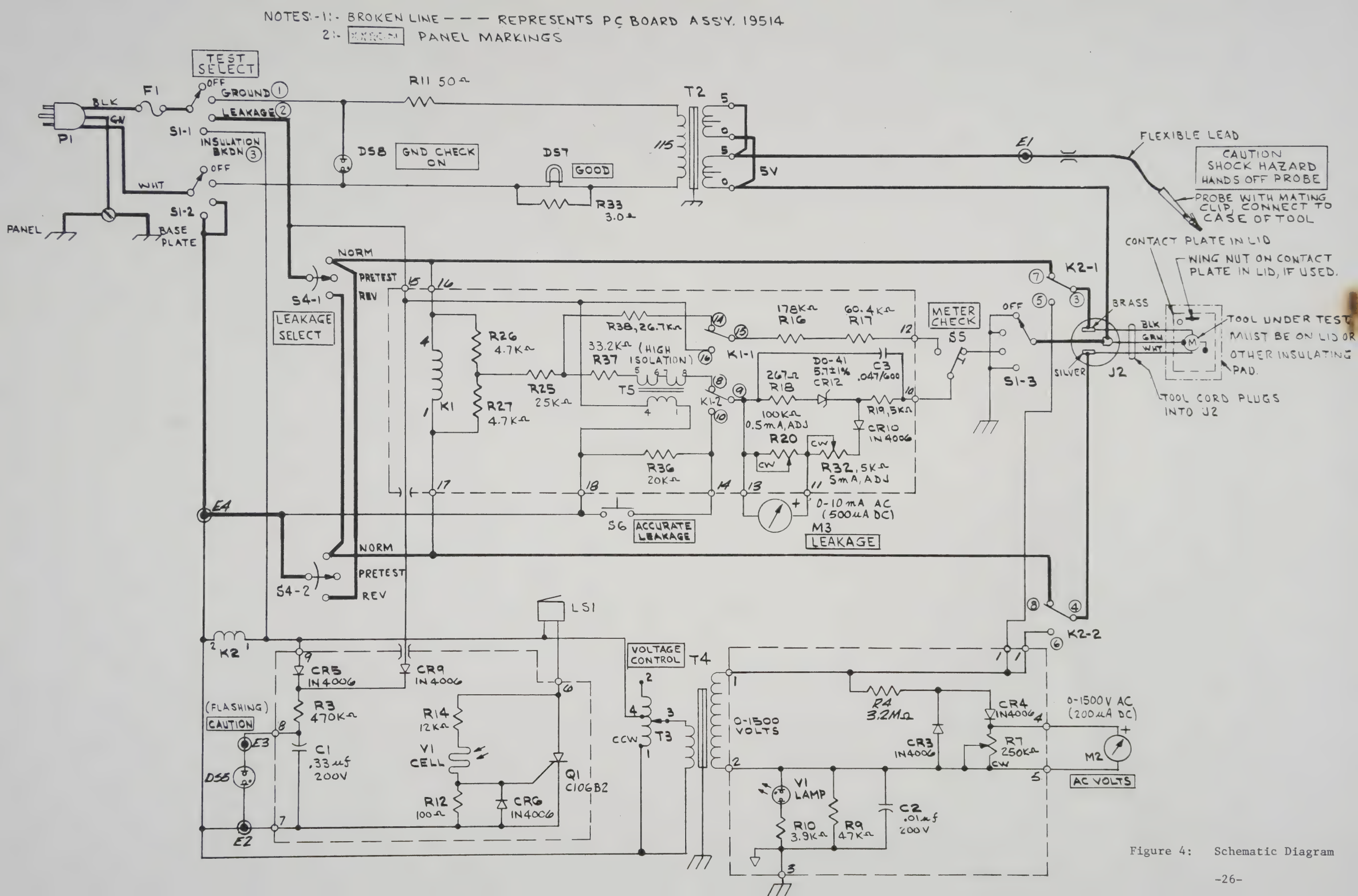


Figure 4: Schematic Diagram

SECTION H

PERFORMANCE CHECK

The procedure given below will insure that all tests are functional. For best results it is required that it be performed on a supply of 120V±2 volts.

> CAUTION
>
> ELECTRIC SHOCK HAZARD

Read Section B, E, and F and follow all safety precautions before proceeding with this check! Before operating this Tester for the first time, you or your supervisor should read this entire manual!

GROUND CHECK

Set Mode Selector Switch to GROUND CHECK; the "ON" pilot lamp should light. Connect the Frame Probe to the bat handle of S4 (remove the probe after the test).
The GOOD lamp should light, fairly bright.
Move the probe to a nearby grounded metal pipe or structure (to test the ground connection of the Tester). The lamp should again light, although it may be dimmer this time.
If either of these tests fail, do not proceed, as the Tester is not properly grounded. Unplug the Tester and find and correct the problem.

LEAKAGE

CAUTION: Do not touch any wires connected to the Test Set when it is operating.

- Isolate the Frame Probe from any local grounds by placing the tip in the lid and arranging the lid to prevent any accidental contact.
- Select the Leakage Test.
- The caution lamp must flash red.
- Make the tests according to Table III on the next page.

If any discrepancies are found, refer to the Repair Sections I and J.

TABLE III
LEAKAGE PERFORMANCE CHECKS

CAUTION!

LEAKAGE SELECTOR	METER CHECK	ACCURATE LEAKAGE	METER READING	PURPOSE
Pre-Test	Press	-	"Meter Check Zone"	Meter Operative and correct supply voltage.
Normal/Reverse	-	Press	"Check Hook-Up Zone"	Amount of Internal Leakage
Selector OFF. Place jumper (1) between the round and upper narrow contact (2) of the Appliance Test Socket.				
Pre-Test	-	-	Midway between 1 & 5	Proves Pre-Test operational.
Normal (2)	-	-	Above 5, less than 10	Proves test is operational.
Normal (2)	-	Press	Above 10	Proves accurate test is operational.
Normal	Press	Press	"Meter Check Zone"	Proves meter check operative during normal leakage testing.

(1) The jumper can be made from a piece of insulated stranded wire of 14 to 18 gauge. A piece about 6 inches long stripped about 1 inch on each end is convenient.

(2) When the test socket jumper is shorted between the ground pin and the narrow contact the Reverse position must result in a meter reading in the "Check Hook-Up" range.

The Test should be repeated with the jumper connected between the round pin and the wide contact of the appliance test socket. The table above applies with the Reverse position selected, and Normal position will result in a "Check Hook-Up" reading.

INSULATION BREAKDOWN

CAUTION-HIGH VOLTAGE!

With the Mode Selector OFF, connect the jumper used for the Leakage Test between the round and narrow contacts of the appliance test socket. Set the Test Voltage Control fully counterclockwise to 0.
Select Insulation Breakdown (with the jumper on J2 in place.) The caution lamp must flash red.

Turn the Test Voltage Control clockwise. The buzzer must sound when the control is between the 5th and 7th mark on the Test Voltage Control scale.

Select OFF, turn the Test Voltage Control to zero and remove the jumper.

Again select Insulation Breakdown and turn up the Test Voltage Control. The Voltmeter will read 1500 volts when the control is between the 8th and 10th mark.

If discrepancies are noted, refer to the Repair Section.

SECTION I

ROUTINE MAINTENANCE

Field service exposes high-voltage test equipment to a difficult environment, but equipment wear can be minimized by periodic inspection and cleaning. Such inspections and cleaning will also ensure reliable on-the-job operation. The frequency of routine inspection and cleaning will depend on the field conditions encountered. For sets operated indoors in a normally dusty atmosphere, this procedure should be performed once every six months. As an extreme, the procedure should be carried out monthly on a set that is used daily outdoors in a heavy dust concentration that is conductive and hygroscopic.

Prior to performing inspection and maintenance, consult any damage reports that may have been completed for the Test Set.

INSPECTION AND MAINTENANCE PROCEDURE

Complete inspection and maintenance procedures can be performed in approximately fifteen minutes. The only equipment required is a screwdriver, an insulated jumper about one foot long, a clean damp cloth, and a clean dry cloth.

Proceed as follows:

1. Visually inspect the case, noting that hinges and case locks function properly. Check for breaks in the case or lid. Note the condition of the carrying strap and case feet.

2. Wipe the outside of the case with the damp cloth; then dry with a clean dry cloth.

3. Open the lid; fully extend and visually inspect all cables. If necessary, wipe each cable with the damp cloth; then dry. Wipe out the lid compartment. Wipe the panel with a clean dry cloth.

4. Visually inspect the panel, noting that all knobs are secure on their shafts and that all controls operate smoothly without binding.

5. Set meters mechanically to zero.

6. Inspect the interior for loose connections or damage.

REMOVAL OF TEST SET FROM CASE

> CAUTION
>
> THE TEST SET MUST BE DISCONNECTED FROM THE SUPPLY AND DE-ENERGIZED BEFORE REMOVING FROM CASE.

To remove the Test Set from the case, proceed as follows:

a. Remove and save the four panel screws.
b. Raise the panel straight up to clear the case.
c. Handle the set only by the panel. Place the set on a clean surface.

COMPLETION OF INSPECTION

a. Wipe the circuit card with a clean dry cloth to remove accumulated dust. Wipe the interior of the case. Visually inspect the interior connections and components.

b. Reinstall the set in the case.

c. Coil the leads and replace them.

d. Perform the check-out procedure of Section H.

If defects are discovered during this inspection see Section on Repair.

SECTION J

REPAIR, TROUBLESHOOTING AND CALIBRATION

REPAIRS

Biddle Instruments maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

Repairs to the Test Set can be made with reference to Section G of this manual, "Functions of Tests Performed and Principle of Operation", the schematic of Figure 4 and the interior view of Figure 5.

The Test Set develops dangerous interior voltages and employs printed circuit card construction, therefore repairs must be made only by qualified persons. The Parts List identifies components and gives the Biddle part number. We recommend that for safety, only Biddle replacement parts be used when making repairs.

TROUBLESHOOTING

TABLE IV
TROUBLESHOOTING PROBLEM AND CAUSE

Problem	Probable Cause
No pilot lamp in GROUND mode.	No voltage at service outlet for the Test Set. Blown fuse. Defective Input Cable. Defective S1.
Leakage Mode No flashing lamp.	As in ground mode or defective CR9, R3 or C1.
Fails to calibrate with S6	Defect on PC card or Meter M3
Insulation Breakdown No flashing lamp. No output	Defective CR5. Defective T3 or T4 or Meter M2. Defect on PC card.
Buzzer does not sound.	Defect in LS1 or components of PC card.

CALIBRATION OF LEAKAGE CURRENT METER

The following items are required.

1. Line supply set to 120V±1. Must be held for all tests.
2. Resistor 1/2 watt metal film 240 K ±1%.
3. Resistor 1/2 watt metal film 24.0 K ±1%.
4. Utility plug to fit the J2 socket with an insulated lead, about 1 foot long, connected to the brass (narrow) blade. The free end of this lead to be fitted with an insulated clip. (Suggest small alligator type with insulated boot.)

Proceed as follows:

CAUTION - SHOCK HAZARD!

a. Using the adjuster, set the mechanical zero of the current meter.
b. Plug the test cable of item 4 into the Tester service socket J2.
c. Connect the 240 K resistor between the clip of item 4 and the clip of the Ground Probe.
d. Insulate the resistor and both clips from Ground and locate the assembly to prevent accidental contact with persons or ground.
e. Set the Mode Selector to "Leakage".
f. Press the "Normal" and the "Accurate" switches.
g. The Leakage Meter must read 0.5 mA ±.05 inches.
h. If it does not, but all components are working, then adjust R20.
i. Set Mode Selector to OFF, replace the 240 K resistor with the 24 K resistor.
j. Select "Leakage", "Normal", "Accurate".
k. The meter must read 5 mA ±.15 inches.
l. If it does not, adjust R32.
m. Recheck both 0.5 mA and 5 mA.
n. Press the Meter Check pushbutton, the meter must now read in the "Meter-Check" zone.

If this cannot be achieved, there is a component defect.

CALIBRATION OF INSULATION BREAKDOWN VOLTMETER

This will require a standard voltmeter verified to read ac 1500V±3%. It must have an impedance of 2000 /Volt or more.

CAUTION-HIGH VOLTAGE

Proceed with the following steps:

a. Using the adjuster, set the mechanical zero of the voltmeter.
b. Set Mode selector to "OFF".
c. Plug item 4 into the Tester, connect the clip of the lead of item 4 to the hot side of the standard voltmeter. (Provide insulation and isolation to personnal and ground).
d. Connect the Tester Ground Probe to the low side of the standard voltmeter.
e. Set Test Voltage Control to zero.
f. Set Mode Selector to Insulation Breakdown.
g. Advance the Voltage Control until the standard meter reads 1500 volts.
h. Read the Test Set meter and adjust R7 until Test Set and standard are in agreement.

DISABLING THE ACCURATE LEAKAGE TEST

This must be done only on authorization. Proceed by the following steps:

a. Locate S6 and unsolder the red lead.
b. Clip off the exposed conductor of the red lead or cover with shrink tubing.
c. Dress the red lead so it is fully insulated from ground and secured.
d. Tag or otherwise note on the Test Set that Accurate Test has been disabled.

SECTION K

PARTS LIST

SYMBOL	DESCRIPTION	PART NO.
C1	Capacitor, 0.33 µF, 200V	4559-41
C2	Capacitor, 0.01 µF, 200V	4559-2
C3	Capacitor, 0.047 µF, 600V	4559-28
CR3	Sil. Rectifier, 1N4006	11637-36
CR4	Sil. Rectifier, 1N4006	11637-36
CR5	Sil. Rectifier, 1N4006	11637-36
CR6	Sil. Rectifier, 1N4006	11637-36
CR9	Sil. Rectifier, 1N4006	11637-36
CR10	Sil. Rectifier, 1N4006	11637-36
CR12	Diode, Zener, 5.7V, 1%	12074-36
DS5	Lamp	17521
DS7	Pilot Light	7449-6
DS8	Lamp Holder	4499-3
	Lamp Type 43 2.5V @ .5 Amp	3612-2
F1	Fuse 15 Amp 250V Type 3AB	2567-34
J2	Receptacle	23062
K1	Relay	16082-3
K2	Relay, DPDT	19507
LS1	Buzzer	14860
M2	Meter, Volts	19509
M3	Meter, Leakage	19510
P1	Input Line Cord	4127-3
Q1	Thyristor	17520
R3	Resistor, 470K, 10%, 1/2W	4501-217
R4	Resistor, 3.2M, 1%, 1W	10646-21
R7	Potentiometer, 250K	12340-16
R9	Resistor, 47K, 5%, 1/2W	4501-169
R10	Resistor, 3.9K, 10%, 1/2W	4501-256
R11	Resistor, 50 , 5%, 70W	17511
R12	Resistor, 100 , 10%, 1/2W	4501-211
R14	Resistor, 12K , 10%, 2W	4501-461
R16	Resistor, 178K, 1%, 1/4W	12026-99

PARTS LIST (cont'd)

SYMBOL	DESCRIPTION	PART NO.
R17	Resistor, 60.4K, 1%, 1/4W	12026-115
R18	Resistor, 267 , 1%, 1/4W	12026-136
R19	Resistor, 5K, 5%, 7W	16601-1
R20	Potentiometer, 100K	12340-14
R22	Resistor, 100K, 5%, 2W	4501-412
R25	Resistor, 25K, 5%, 5W	16601-2
R26	Resistor, 4.7K, 10%, 2W	4501-456
R27	Resistor, 4.7K, 10%, 2W	4501-456
R29	Resistor, 170K, 12.5W	4505-21
R32	Potentiometer, 5K	12340-9
R33	Resistor, 3 , 5%, 3W	4500-2
R36	Resistor, 20K 10W	4500-84
R37	Resistor, 33.2K 1%, 1/4W	12026-5
R38	Resistor, 26.7K 1%, 1/4W	12026-46
S6	Switch	17516-1
T2	Transformer	17522-1
T3	Autotransformer	6408-2
T4	Transformer	17938
T5	Transformer	19108-2
V1	Opto-isolator	14865-1

RECOMMENDED SPARE PARTS

	QUANTITY		
F1	5	FUSE 15 Amp 3AB	2567-34
DS7	1	"GOOD" Lamp Type 43	7449-6
Frame Probe Assy.	1		23060

SECTION L

WARRANTY

All products supplied by the Biddle Instruments are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps, or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.